

SUPPORT FOR THE AMENDMENT

This Amendment amends the specification; amends Claims 1-2, 4, 6, 8-10, 15 and 17-20; and adds new Claims 21-24. Support for the amendments is found in the specification and claims as originally filed. In particular, support for Claim 2 is found in the specification at least at page 44, lines 11-22. Support for new Claims 21 and 24 is found in the specification at least at page 26, line 9 to page 27, line 4. Support for new Claim 22 is found at least in Claim 10. Support for new Claim 23 is found at least in Claim 6. No new matter would be introduced by entry of these amendments.

Upon entry of these amendments, Claims 1-24 will be pending in this application. Claims 1, 2, 4 and 15 are independent.

REQUEST FOR RECONSIDERATION

Applicants respectfully request entry of the foregoing and reexamination and reconsideration of the application, as amended, in light of the remarks that follow.

The present invention provides a non-aqueous electrolyte, and a secondary battery including the non-aqueous electrolyte. The non-aqueous electrolyte comprises a non-aqueous solvent containing ethylene carbonate (EC), γ -butyrolactone (BL), and at least one selected from the group consisting of ethylene sulfite, phenylethylene carbonate, 2-methylfuran, furan, thiophene, catechol carbonate, and vinylethylene carbonate as a third solvent. The third solvent makes it possible to form a dense protective film on the surface of the negative electrode of the secondary battery. As a result, the reaction between the negative electrode and the γ - butyrolactone in a high temperature environment can be suppressed. This improves the charge-discharge cycle life of the secondary battery in the high temperature environment. See, specification at page 41, lines 10-23.

Claim 1 is rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 5,993,997 ("Fujimoto") in view of EP 0 759 641 ("Mao"). In addition, Claims 2-14 are rejected under 35 U.S.C. § 103(a) over Fujimoto and Mao and further in view of U.S. Patent No. 6,048,639 ("Sonozaki"). Claims 15-20 are rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 6,465,134 ("Shibuya") in view of Mao and Sonozaki.

Fujimoto discloses lithium secondary batteries comprising a non-aqueous solvent consisting of ethylene carbonate (EC) and γ -butyrolactone (BL). Fujimoto at column 21, Example 18. However, the Office Action admits that Fujimoto does not suggest the addition of any of the recited third solvents. Office Action at page 2, lines 22-23.

Shibuya discloses lithium batteries comprising a gel electrolyte containing ethylene carbonate (EC), propylene carbonate (PC) and γ -butyrolactone (BL). Shibuya at column 5, 16-18. The Office Action admits that Shibuya does not suggest the addition of any of the recited third solvents. Office Action at page 4, lines 9-10.

Sonozaki is cited for disclosing battery casings with walls less than 0.3 mm thick.

Mao discloses non-aqueous rechargeable lithium batteries can be protected against overcharge abuse by incorporating small amounts of suitable aromatic additives, such as furan, into the electrolytes of the batteries. Mao at abstract.

However, in contrast to the present invention, Mao fails to suggest the combination of ethylene carbonate (EC), γ -butyrolactone (BL) and the recited third solvent. Mao also fails to suggest the improvement in charge-discharge cycle life resulting from the addition of the recited third solvent to battery electrolyte. Mao discloses a FIG. 3, reproduced below.

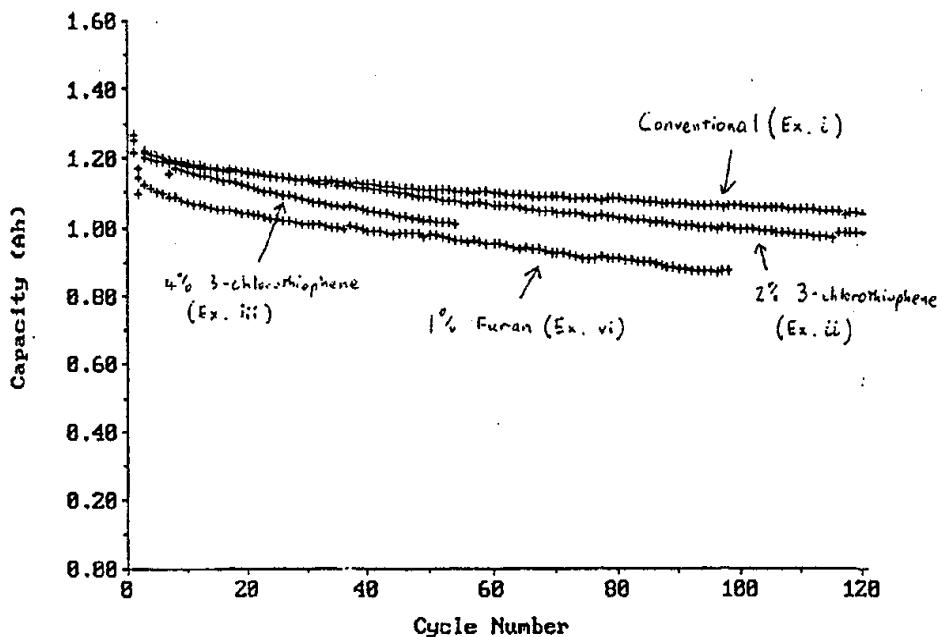


FIG. 3

Mao discloses in FIG. 3 a conventional secondary battery (Ex. i) using a non-aqueous solvent containing ethylene carbonate (EC) and diethyl carbonate (DEC) in a volume ratio of 30:70 exhibits an initial-cycle capacity of about 1.2 Ah and a 120-th cycle capacity of larger than 1 Ah. Mao at page 6, lines 45-47. Mao also discloses a secondary battery containing 1% furan in a non-aqueous solvent (Ex. vi) exhibits an initial-cycle capacity lower than that of conventional Ex. i and a 100-th cycle capacity of as low as 0.9 Ah. Mao at page 7, lines 35-38. Mao discloses that the data for the battery of Ex. vi is similar to that for the conventional battery of Ex. i. Mao at page 7, lines 38-39. However, in contrast to the present invention, Mao fails to disclose an improvement in charge-discharge cycle life.

The presence of the recited third solvent in the ethylene carbonate (EC) and γ -butyrolactone (BL) improves the charge-discharge cycle life of a battery. The specification discloses at pages 51-53, Tables 1-3 (reproduced below), that Examples 1-25 of the present invention, which include the recited third solvent, exhibit capacity retention rates of 87 to 95% at 45°C. The capacity retention rates (%) are obtained at the 100-th cycle and are relative to the 1-st cycle (corresponding to 100%) when the charge-discharge cycle is performed at 45°C. See, specification at page 48, line 27 to page 49, line 25.

Table 1

	Nonaqueous solvent	Solute	Solute concentration (mol/L)	Maximum discharge capacity (Ah)	Capacity retention rate (%)	Swelling (%)
Example 1	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% ES;	LiBF ₄	1.5	0.52	95	1
Example 2	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% phEC;	LiBF ₄	1.5	0.52	87	1
Example 3	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% 2Me-F;	LiBF ₄	1.5	0.52	90	2
Example 4	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% F;	LiBF ₄	1.5	0.52	88	2
Example 5	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% TiOP;	LiBF ₄	1.5	0.52	93	2
Example 6	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% CATC;	LiBF ₄	1.5	0.52	92	1
Example 7	mixed solvent of EC and BL (volume ratio 33:67) 99.5 wt%, 0.5 wt% VEC;	LiBF ₄	1.5	0.52	95	1
Example 8	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% ES;	LiBF ₄	1.5	0.50	90	1
Example 9	mixed solvent of EC and BL (volume ratio 33:67) 96 wt%, 4 wt% phEC;	LiBF ₄	1.5	0.52	87	1
Example 10	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% 2Me-F;	LiBF ₄	1.5	0.51	90	2

Table 2

	Nonaqueous solvent	Solute	Solute concentration (mol/L)	Maximum discharge capacity (Ah)	Capacity retention rate (%)	Swelling (%)
Example 11	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% F;	LiBF ₄	1.5	0.50	88	2
Example 12	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% TiOP;	LiBF ₄	1.5	0.50	93	2
Example 13	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% CATC;	LiBF ₄	1.5	0.50	92	1
Example 14	mixed solvent of EC and BL (volume ratio 33:67) 98 wt%, 2 wt% VEC;	LiBF ₄	1.5	0.52	93	1
Example 15	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% ES;	LiBF ₄	1.5	0.43	87	2
Example 16	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% pHEC;	LiBF ₄	1.5	0.48	90	2
Example 17	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% 2Me-F;	LiBF ₄	1.5	0.45	90	4
Example 18	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% F;	LiBF ₄	1.5	0.43	88	4
Example 19	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% TiOP;	LiBF ₄	1.5	0.43	90	4
Example 20	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% CATC;	LiBF ₄	1.5	0.43	91	3
Example 21	mixed solvent of EC and BL (volume ratio 33:67) 93 wt%, 7 wt% VEC;	LiBF ₄	1.5	0.48	87	2

Table 3

	Nonaqueous solvent	Solute	Solute concentration (mol/L)	Maximum discharge capacity (Ah)	Capacity retention rate (%)	Swelling (%)
Example 22	mixed solvent of EC and BL (volume ratio 40:60) 99.5 wt%, 0.5 wt% ES;	LiBF ₄	1.5	0.52	93	1
Example 23	mixed solvent of EC and BL (volume ratio 25:75) 99.5 wt%, 0.5 wt% ES;	LiBF ₄	1.5	0.52	92	1
Example 24	mixed solvent of EC and BL (volume ratio 40:60) 99.5 wt%, 0.5 wt% VEC;	LiBF ₄	1.5	0.52	94	1
Example 25	mixed solvent of EC and BL (volume ratio 25:75) 99.5 wt%, 0.5 wt% VEC;	LiBF ₄	1.5	0.52	93	1

In contrast, the specification discloses at page 54, Table 4 (reproduced below), that in Comparative Examples 3, 4, 6 and 8, which include ethylene carbonate (EC) and γ -butyrolactone (BL), but lack the recited third solvent, the capacity retention rate is a maximum of only 75%.

Table 4

	Nonaqueous solvent	Solute	Solute concentration (mol/L)	Maximum discharge capacity (Ah)	Capacity retention rate (%)	Swelling (%)
Comparative Example 1	100 vol.% BL	LiBF ₄	1.5	0.30	10	1
Comparative Example 2	25 vol.% EC, 50 vol.% BL, 25 vol.% MEC	LiBF ₄	1.5	0.30	20	100
Comparative Example 3	75 vol.% EC, 25 vol.% BL	LiBF ₄	1.5	0.40	30	20
Comparative Example 4	1 vol.% EC, 99 vol.% BL	LiBF ₄	1.5	0.35	10	10
Comparative Example 5	25 vol.% EC, 75 vol.% MEC	LiPF ₆	1.5	0.52	0.1	50
Comparative Example 6	33 vol.% EC, 67 vol.% BL	LiBF ₄	1.5	0.52	75	1
Comparative Example 7	40 vol.% EC, 60 vol.% BL	LiBF ₄	1.5	0.52	75	1
Comparative Example 8	25 vol.% EC, 75 vol.% BL	LiBF ₄	1.5	0.52	75	1
Comparative Example 9	33 vol.% EC, 66 vol.% BL, 1 vol.% VC	LiBF ₄	1.5	0.52	79	2

Thus, the specification shows that the inclusion of the recited third solvent with ethylene carbonate (EC) and γ -butyrolactone maintains the battery capacity better (i.e., higher capacity retention rate) than conventional batteries with only ethylene carbonate (EC) and γ -butyrolactone (BL). As a result, batteries with ethylene carbonate (EC), γ -butyrolactone (BL), and the recited third solvent have improved charge-discharge cycle life relative to the conventional batteries.

Because the cited prior art is silent about capacity retention rate and fails to suggest the improvement in charge-discharge cycle life achieved in the present invention by the combination of ethylene carbonate (EC), γ -butyrolactone and the recited third solvent; and because conventional batteries as discussed above, with ethylene carbonate (EC) and γ -butyrolactone but none of the recited third solvent, have capacity retention rates of 75% or less, the cited prior art fails to suggest the independent Claim 2 limitation that "the capacity retention rate at a 100-th charge-discharge cycle is at least 85%". Thus, the prior art rejection as it applies to Claim 2-3 should be withdrawn

Furthermore, any *prima facie* case of obviousness based on the cited prior art is rebutted by the significant improvement in capacity retention rate achieved according to the inventions of independent Claims 1, 2, 4 and 15 using the nonaqueous solvent containing ethylene carbonate, γ - butyrolactone and at least one of the recited third solvents. The cited prior art fails to suggest the significant improvement in capacity retention rate from the conventional 75% to the 87-95%, as discussed above, that is achieved by the present invention by the inclusion of the recited third solvents in the nonaqueous solvent. Because any *prima facie* case of obviousness is rebutted, the various rejections under 35 U.S.C. § 103 should be withdrawn.

In view of the foregoing amendments and remarks, Applicants respectfully submit that the application is in condition for allowance. Applicants respectfully request favorable consideration and prompt allowance of the application.

Should the Examiner believe that anything further is necessary in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,

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